UNITED STATES DEPARTMENT OF AGRICULTURE
SOIL CONSERVATION SERVICE
WASHINGTON, D. C.
H. H. BENNETT, CHIEF

ADVANCE REPORT

on the

SEDIMENTATION SURVEY OF LAKE OLATHE

OLATHE, KANSAS

May 26 to June 4, 1937

by

Victor H. Jones

Sedimentation Studies
Division of Research
SCS-SS-24
July 1938

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INTRODUCTION

The sedimentation survey of Lake Olathe was made during the period May 26 to June 4, 1937, by the Section of Sedimentation Studies, Division of Research, Soil Conservation Service, in cooperation with the Kansas Agricultural Experiment Station. The survey party consisted of Louis M. Seavy, in charge, Arnold B. Taylor, Earl H. Moser, Jr., Harold R. New, Jonas Spitler, and Duncan T. Axford. Preliminary data were secured and arrangements for the survey were made by F. F. Barnes. Studies of the lake sediment and an inspection of the drainage basin were made by Victor H. Jones, assisted by the field party. F. L. Duley, field representative of the Research Division, assisted in arranging cooperative agreements and in coordinating the field program.

Moisture determinations and mechanical analyses of the sediment samples were made under the direction of Professor W. H. Metzger in the soils laboratories of Kansas State College at Manhattan.

Blueprints of the dam and an original contour map of the reservoir basin were furnished by E. T. Archer and Company, consulting engineers, of Kansas City, Missouri.

The cooperation and assistance of the Olathe municipal officials, especially D. M. Ashlock, mayor, and W. K. Tainter, city clerk, greatly facilitated the survey of Lake Olathe. Boats for the range work, material for monuments, and information on the history and cost of the reservoir were furnished by the city. George Lehman, caretaker of the lake, supplied information on high and low water stages in the reservoir.

George S. Knapp, chief engineer of the Division of Water Resources, Kansas State Board of Agriculture, supplied information on a large number of lakes in Kansas, which was of great assistance in selecting reservoirs for detailed study.

GENERAL INFORMATION

Location (fig. 1):

State: Kansas.

County: Johnson. Secs. 10, 11, and 15, T. 14 S., R. 23 E.

Distance and direction from nearest city: Lake Olathe dam is 3 miles southwest of Olathe.

Drainage and backwater: Cedar Creek, a tributary of the Kansas River.

Ownership: City of Olathe.

Purpose: Auxiliary municipal water supply and recreation.

Description of dam.

The dam is an earth-fill structure, 750 feet long including the spillway, 31.5 feet in height above the stream bed, and 15 feet wide at the top (fig. 2). It is reinforced and made watertight by a concrete core wall extending from crest to bedrock. Both the upstream and downstream faces have slopes of $2\frac{1}{2}$:1, and the former is faced with rock riprap to the top.

The spillway consists of a gently sloping concrete apron in the west end of the dam. The spillway crest is 145 feet long, 4.5 feet below the top of the dam, and 27 feet above stream bottom. The crest elevation, although not yet precisely determined, is about 975 feet above sea level. The spillway will carry a flood flow of 3,000 cubic feet per second.

The dam is provided with a sluiceway 4 feet square which traverses the bottom of the earth fill at the stream channel. Prior to construction it was hoped that the sluiceway would provide means of flushing large quantities of sediment from the lake, but its efficiency has not yet been tested. At the time of the survey the water of Lake Olathe was used only as an emergency supply. It is drawn off near the surface by means of gate valves in the intake well and discharged into the creek valley below the dam. Thence it flows into a smaller reservoir in the same valley about 1 mile downstream.

FIGURE 1

MAP SHOWING LOCATION OF

LAKE OLATHE

Figure 2.--Lake Olathe dam and spillway.

Figure 3.--Channel of Cedar Creek 0.6 mile above the head of the north arm of Lake Olathe.

Historical record.

The dam was completed and storage begun on July 4, 1932, and at the time of the survey the age of the reservoir was 4.9 years. In 1935 a flood raised the lake level until the dam was overtopped and somewhat eroded on the lower side by overflow waters. Notching of the top of the dam, however, was prevented by the concrete core wall. The water level normally varies between 2 and 4 feet below spillway level and flows over the spillway only for 4 or 5 days at a time after unusually heavy rains.

The total cost of the reservoir, including construction of the dam and purchase of property, was $42,365.

Length of lake: 1.21 miles.

Area of lake at spillway stage: 58 acres. There had been no reduction by sedimentation up to the date of survey.

Storage capacity to spillway level:

	Acre-feet	
Original.....	532	(173,300,000 gals.)
At date of survey.....	477	(155,400,000 gals.)
Reduction by sedimentation.....	55	(17,900,000 gals.)

General character of reservoir basin.

Lake Olathe is impounded in the small moderately sinuous valley of Cedar Creek and extends as two arms of nearly equal size into the two branches that unite to form the main valley about two-thirds of the way from the dam to the head of backwater. (See fig. 4, following p. 14.) The reservoir has a fairly smooth shore line and decreases more or less gradually in width upstream from a maximum of 700 feet near the dam.

Submerged slopes along the shore descend to the valley bottom with an inclination of 5 to 10 percent. Areas of flat bottom are of limited extent, as the valley is youthful and has a broadly V-shaped cross section. The submerged original channel had an average width of about 15 feet, a depth of 3 to 5 feet below adjacent areas of the valley bottom, and an average gradient through the reservoir basin of about 24 feet per mile. The gradient of the submerged valley bottom is about the same, because the channel follows a fairly direct course through it.

Area of drainage basin: 6.2 square miles, as measured by planimeter on the soil map of Johnson County.[1]

General character of drainage basin.

Geology.--The bedrock formations at and near the surface within the watershed are limestones and shales belonging to the Kansas City and Lansing groups of the Missouri (middle Pennsylvanian) series. The following generalized stratigraphic section was compiled from field notes made during the survey and from publications of the Kansas Geological Survey.[2]

Generalized section of strata in the Lake Olathe drainage basin

	Thickness in feet
Pennsylvanian:	
Missouri series:	
Lansing group:	
Stanton formation--	
Limestone, dark gray, some shale beds...	24
Vilas formation--	
Shale, dark gray, fossiliferous.....	11
Plattsburg formation--	
Limestone, gray and buff, fossiliferous, some shale beds.....	24
Merriam formation--	
Limestone, dark gray, dense.....	15
Kansas City group:	
Bonner Springs formation--	
Shale, brown and gray, sandy.....	27
Wyandotte formation--	
Limestone, gray and buff.....	52
	153

[1]Knobel, E. W., and Davis, R. H. Soil survey of Johnson County, Kansas. U. S. Dept. Agr., Bur. Chem. and Soils, Ser. 1928, Rept. 17.

[2]Moore, R. E. Stratigraphic classification of the Pennsylvanian rocks of Kansas. Kans. Geol. Survey Bull. 22, 1936.
_____, Landes, K. K., and others. Geologic map of Kansas. Kans. Geol. Survey, Scale 1/500,000, 1937.
Nowell, Norman D. The geology of Johnson and Miami Counties, Kansas. Kans. Geol. Survey Bull. 21, 1935.

The Stanton limestone crops out at Lake Olathe dam and overlies older strata in the bluffs of Cedar Creek valley below the lake. The entire drainage basin lies within the outcrop area of the Stanton formation, which is predominantly limestone but includes some relatively thin interbedded shales.

A thin layer of mantle rock beneath the soil covers the bedrock in some parts of the area. It ranges from a few inches to about 2 feet in thickness and contains some material not derived from underlying formations. Much of it may be loess of Pleistocene and Recent age, and it contains erratic pebbles of chert and igneous rocks which may be outwash from glacial drift along the Kansas River valley. The loess and rare erratic pebbles are mixed with considerable silt and clay produced by weathering of the underlying limestone and shale strata.

Topography and drainage.--The Lake Olathe drainage basin lies in the Osage Hills section of the Central Lowlands physiographic province. Elevations in the drainage area range from about 975 feet above sea level at the reservoir to about 1,070 feet at the eastern boundary. The area is an upland plain of low relief with predominantly gentle slopes, few of which exceed 4 percent. Limestone ledges along the south shore of the lake near the dam form low bluffs rising about 12 feet above crest level.

The drainage is consequent upon the gentle westward slope of the plain and is typically dendritic (fig. 5). All streams are intermittent (fig. 3), and the stream gradients average about 30 feet per mile. The valleys are broadly V-shaped in cross section, and none exceed 40 feet in depth. There are no bottomlands, the only relatively flat areas in the basin being on the uplands.

Soils.--The soils of the entire drainage basin are silt loams belonging to the Summit, Labette, Parsons, and Verdegris series.[3] Table 1 lists the characteristics and relative areas of the important soil types.

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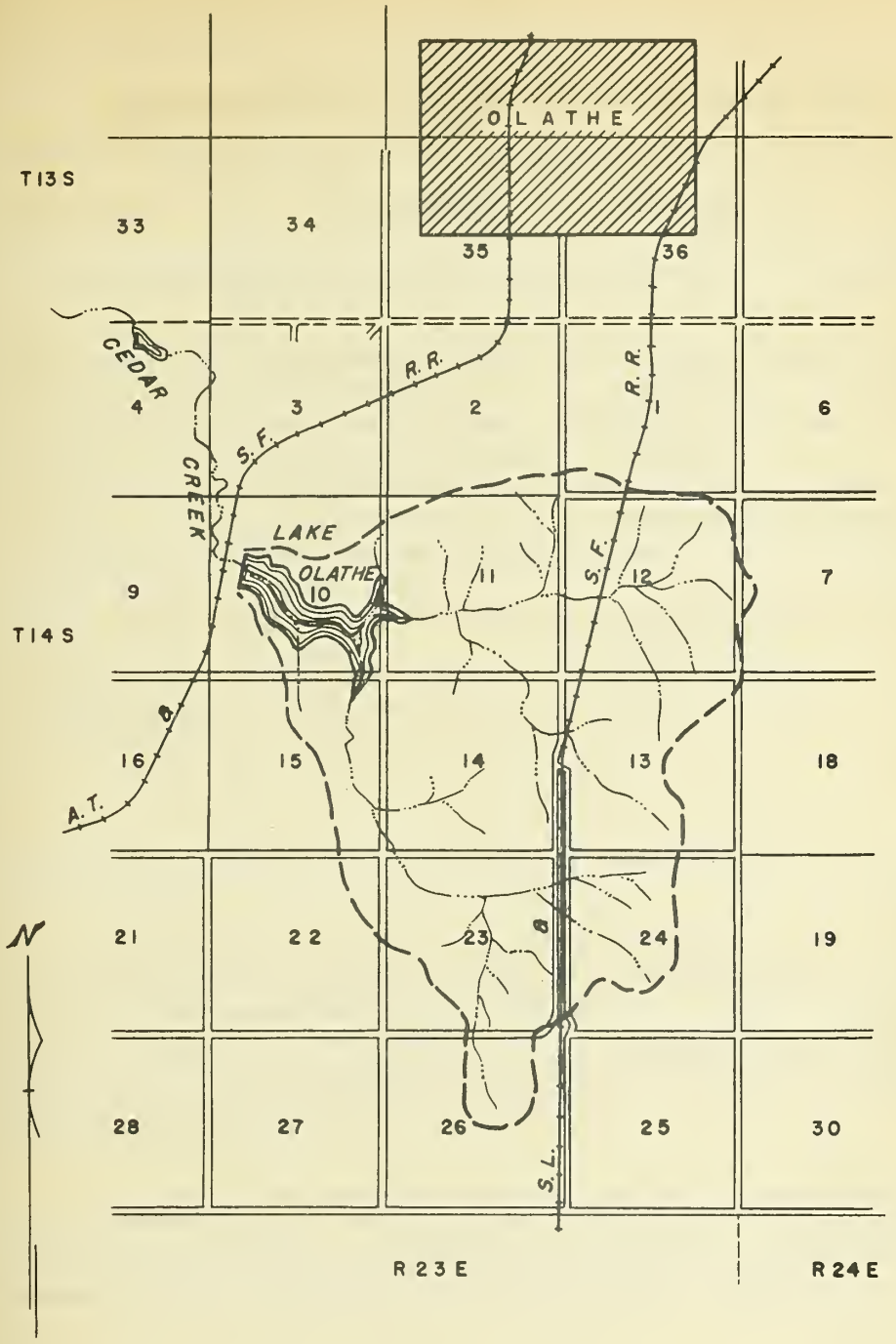
[3]See footnote 1 on page 4 (p. 6, soil map).

Figure 5



LAKE OLATHE DRAINAGE BASIN

JOHNSON COUNTY, KANSAS

SCALE

0 1/2 1 2

WATERSHED BOUNDARY

INTERMITTENT STREAMS

LAKE

Table 1.--Soils of the Lake Olathe drainage basin

Soil type	Description	Occurrence	Proportionate area
			Percent
Summit silt... loam.	Dark-brown heavy.. silt loam.	On highest flat..... uplands.	79.1
Labette silt.. loam.	Brown or reddish-brown silt loam.	Slopes near main..... valleys.	13.4
Parsons silt.. loam.	Grayish-brown heavy clay-pan soil.	One gently sloping... area on clay-shale.	2.9
Verdegris..... silt loam.	Loose brown sandy.. silt loam.	Along streams.....	1.3
Bates silt.... loam.	Brown sandy silt... loam.	In valleys on..... sandy shale.	0.6
Undifferen-... tiated stony silt loams.	Stony and sandy.... silt and clay loams.	Steeper slopes..... near the lake.	2.7
			100.0

More than 90 percent of the soils in the area are relatively heavy silt loams ranging in color from grayish brown to reddish brown. Their thickness ranges from 4 feet on some relatively flat areas of upland to less than 1 foot on areas of the Parsons clay-pan soil. The only loose sandy soils are those of the Bates and Verdegris series, which have an aggregate area of only 1.9 percent of the drainage area.

Land use.--The drainage area is entirely agricultural, and more than 70 percent of the land is cultivated. Approximate figures on land use were obtained by automobile traverse during the survey and are summarized in the following tabulation.

Land use in the Lake Olathe drainage basin (1937)

Use	Proportionate area
	Percent
Cultivated land:	
Wheat	25
Corn	24
Oats	13
Hay crops	8
Gardens and orchards	2
Total cultivated land	72
Pasture land:	
Open	15
Wooded	12
Total pasture land	27
S. L. & S. F. Railroad	1
Total drainage area	100

All the steeper slopes near the lake shore have been developed as a park by the city. The sparse growth of hardwood trees around the lake is being protected, and grass and oats have been planted to check erosion near the shore. In more remote parts of the area most of the valleys are in pasture, and only the more gently sloping uplands are cultivated.

Erosion conditions.--Sheet erosion has already become a problem on the land above the reservoir and occurs at an excessive rate throughout most of the cultivated areas. Much soil is being removed by run-off waters from practically all cultivated areas, even though the slopes are relatively gentle. No large gully systems have developed, although small rivulets produced by heavy rains have cut through the soil to bedrock in many places. Downcutting of gullies, and consequently their lateral growth, is limited by the resistant limestones and dense, impervious shales that underlie the soil. The drainage basin was not examined in sufficient detail to delineate accurately the areas

of greatest erosion, but it is known that sheet erosion is relatively vigorous near the creek valleys in sections 10, 11, and 15 (fig. 5).

Mean annual rainfall: 37.73 inches, according to records of the United States Weather Bureau station at Olathe, Kans.

Draft on reservoir.

Lake Olathe, up to the time of the survey, had furnished only a small part of the municipal water supply, as it had been used only to augment the storage of an older smaller reservoir 1 mile downstream on Cedar Creek. Water consumption of Olathe ranges from about 5,000,000 gallons per month during the winter season to 9,000,000 gallons per month during July and August.

METHOD OF SURVEY

The measurement of water and sediment volumes in Lake Olathe was accomplished by the range method of survey developed by Eakin.[4] A primary control system of 33 points was established by plane-table triangulation from a chained base line 910 feet long extending across the dam. The spillway-level contour was then mapped by plane table and telescopic alidade on a scale of 1 inch to 200 feet. For the measurement of sediment thickness and water depth 33 ranges were established across the reservoir at suitable positions. All range ends and important triangulation points were permanently marked with concrete monuments 6 inches in diameter and 2 feet long placed with their tops flush with ground level. The appropriate survey numbers were stamped on metal plates imbedded in the tops of the monuments, which will serve as a base for future resurveys.

Four samples of bottom sediment from various parts of the lake were taken with the 1⅛-inch tubular sampler described in a previous report.[5] The samples were obtained in 1½-inch iron pipe nipples 4 inches long, which were immediately removed from the

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[4]Eakin, H. M. Silting of reservoirs. U. S. Dept. Agr. Tech. Bull. 524: 25-28, 129-135, 1936.

[5]Jones, V. H. Advance report on the sedimentation survey of Lake Braken, Galesburg, Illinois. U. S. Soil Conserv. Serv., SS-14, p. 7, 1937 (Mimeographed).

sampler and capped with threaded airtight iron covers for shipment to the laboratory.

A capacity curve (fig. 6), showing water-storage capacities at the time of the survey, was prepared by means of 1-foot contours on the silt surface drawn from sounding data.

SEDIMENT DEPOSITS

Character of Sediment

As shown by analysis (table 3), the principal constituents of the reservoir sediment in relative order of abundance are: (1) sand, (2) clay, and (3) silt. Most of the sand is so fine, however, that in field identification the sediment in general would be classified as predominantly silt. The proportion of clay decreases upstream from the dam, and the sand fraction is largest near the heads of the two arms. Material coarser than medium sand is very scarce in the lake deposits, because practically all the sediment is derived from the weathering of relatively pure limestone and shale. Most of the lake sediment is loose and incoherent, having undergone little compaction. Above ranges R27 and R18 near the heads of the two arms, however, the sediment has been compacted by drying during low lake stages.

The location, depth relations, and moisture content of the four sediment samples taken during the survey are given in table 2.

Figure 6

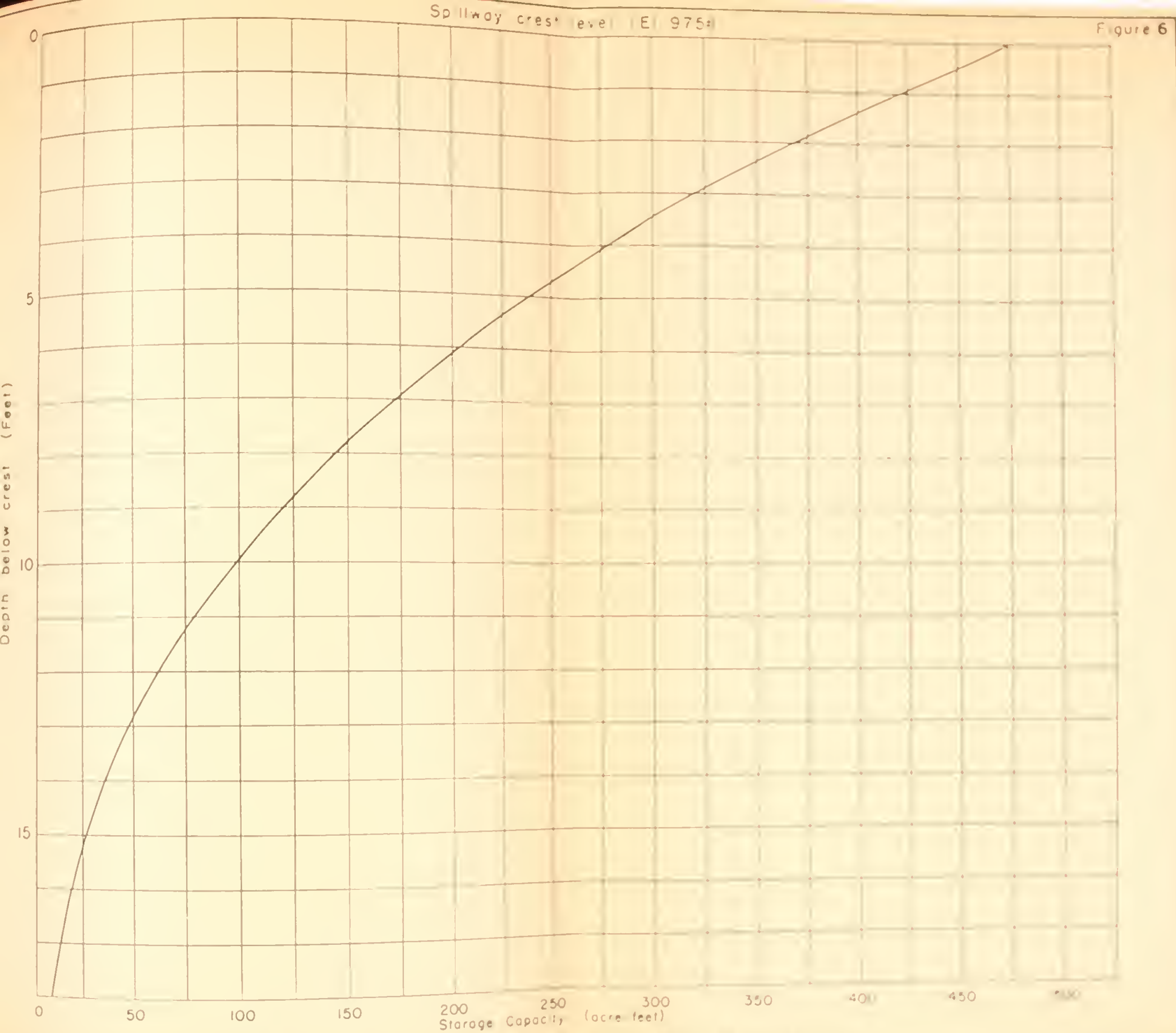

Figure 6. Storage-Capacity Curve, June 1937, Lake Olathe, Olathe, Kans

Table 2.--Bottom-sediment samples from Lake Olathe

Sample No.	Location	Water depth	Sediment thickness	Penetration[1]	Relation of moisture to dry weight of sediment.
		Feet	Feet	Feet	Percent
47....	Range R5, 158 feet from R5L.....	20.8	3.7	3.7	86.5
53....	Range R1, 385 feet from R1L.....	22.8	3.4	3.3	55.3
54....	Range R10, 196 feet from R10L.....	15.8	4.7	4.7	66.3
55....	Range R22, 189 feet from R22R.....	8.9	4.7	4.7	57.8

[1]Depth to which lower end of sampler penetrated sediment.

On the basis of the moisture determinations and an assumed specific gravity of 2.6 for the sediment, the average dry weight of the reservoir sediment was computed as 60.4 pounds per cubic foot.

The results of mechanical analyses of the four sediment samples are given in table 3. The analyses were made by the hydrometer method and consequently are only approximate. The sand fraction, including all material coarser than 0.05 millimeter, consists chiefly of fine and very fine sand.

Table 3.--Mechanical composition of sediment samples from Lake Olathe

Sample number	Sand >0.05 mm	Silt 0.05 to 0.005 mm	Clay <0.005 mm
	Percent	Percent	Percent
47	55.9	10.7	33.6
53	53.9	14.5	32.6
54	54.4	19.2	26.2
55	57.1	25.3	17.6

The color of the sediment is prevailingly dark brown but ranges from nearly black in deep water near the dam to grayish brown near the heads of the arms. Indistinct black streaks caused by carbonized vegetal debris occur at several levels in the thickest parts of the deposit.

Nearly everywhere the distinction between the lake sediment and the underlying valley material is sharp. Dark-brown valley soils, consisting chiefly of Verdegris and Labette silt loams (including stony phases), underlie the lake deposits in the greater part of the basin. The soils are much more compact than the lake sediment and contain numerous roots of grass and other plants. The creek channel beneath the sediment traverses shale and limestone strata, fragments of which were brought up by the silt-measuring apparatus during the range work. In some parts of the basin a thin mat of leaves and twigs, washed into the reservoir by the first inflow, lies beneath the sediment.

Distribution of Sediment

Except for minor irregularities occasioned by the rough topography of the reservoir basin, the sediment in Lake Olathe has a fairly uniform distribution (fig. 7). In general, the deposits are thickest in the channel and other relatively deep parts of the basin, somewhat thinner on the adjacent submerged valley bottom, and absent within about 100 feet of the spillway-level shore line.

On range R2, 400 feet above the dam (fig. 4, following p. 14), the deposit has a maximum thickness of 3.4 feet in the channel, decreases to 1 foot within 75 feet in each direction, and is practically absent within 75 feet of each shore. The average thickness between the channel and shore zones is about 0.6 foot. The maximum water depth on this range is 22.8 feet.

In general, the thickness and lateral distribution of sediment on range R2 are typical of the entire basin as far upstream as ranges R16 and R25 on the north and south arms, respectively. Above these ranges the narrow ponded-channel sections of the reservoir are subject to alternate scour and fill. At the time of the survey they contained deposits in the deeper parts ranging from 0.6 foot to 3.3 feet in thickness. Local concentrations of sediment about 5 feet thick occur in scoured areas of the submerged channel on ranges R1 and R10.

In only one area of appreciable size has sediment accumulated above crest level to date. A small triangular delta about 0.5 acre

Figure 7

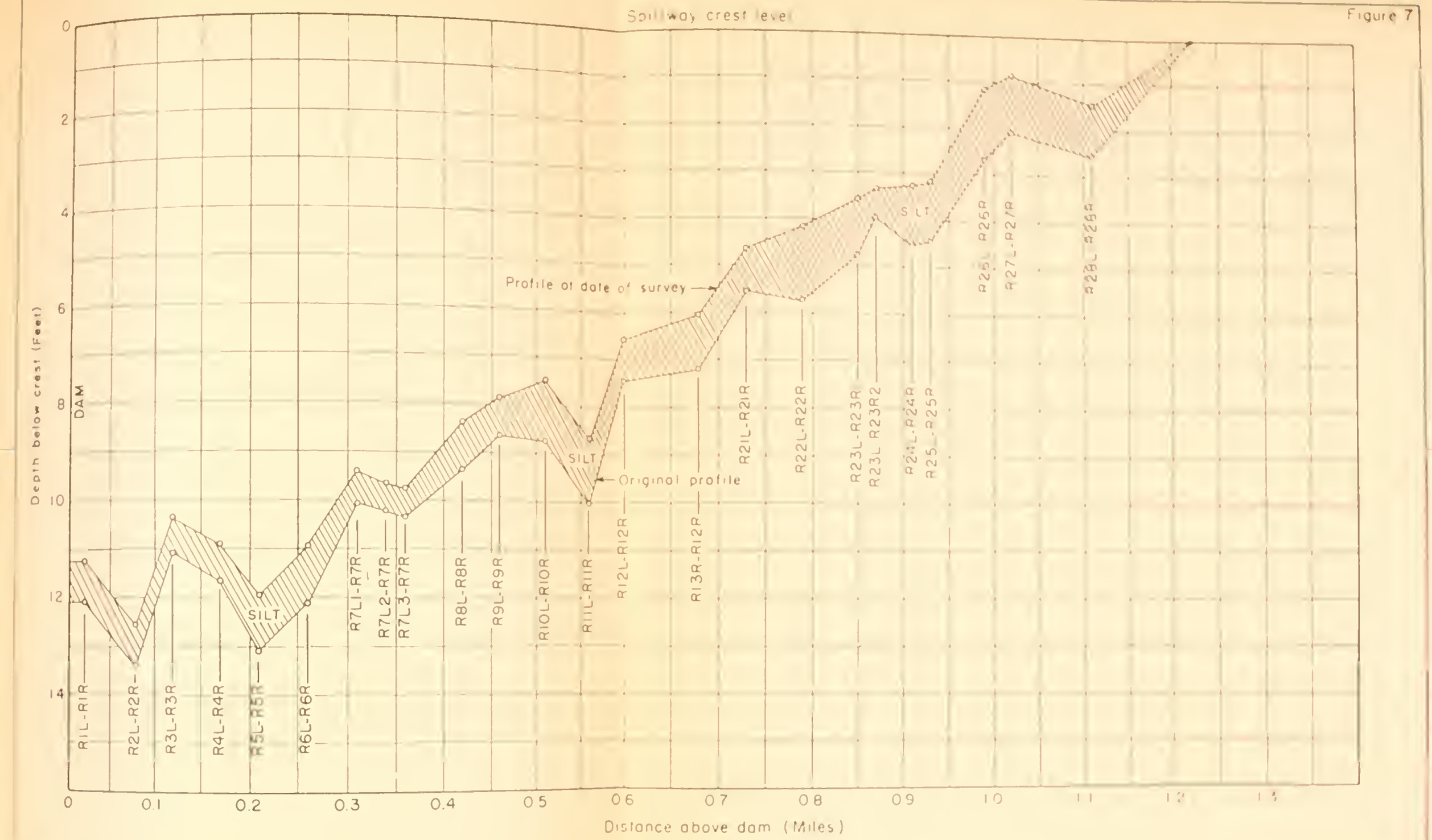

FIGURE 7.-Average-depth profiles, Lake Olathe, Olathe, Kansas

6 14 38 0 2226

in area occurs above the road fill at range end R7L2 (fig. 4). A 10-inch culvert at crest level is the only connection between water of the tributary and the lake, and consequently the road fill has served as a sediment trap. It has caused deposition of an estimated 1.5 acre-feet of sediment which otherwise would have been added to the main reservoir deposit.

Debris from wave erosion originates almost entirely from the fine silt loam in a narrow belt extending 2 to 4 feet below crest level and about 1 foot above it. This fine material is stripped away and carried into deeper parts of the basin, and further erosion is limited by the limestone thus exposed. As the soil mantle is comparatively thin little or no "notching" by the waves has occurred.

Origin of Sediment

A reconnaissance examination of the drainage area has indicated that nearly all the sediment in Lake Olathe has originated by sheet erosion, which is most vigorous near the main stream in sections 10, 11, and 15 (fig. 5). Minor sources of sediment are small, shallow gullies, chiefly in cultivated fields in the above-mentioned area, and wave action along the lake shore. Some of the material moved from cultivated slopes by sheet erosion becomes stabilized for a time at the foot of the steeper slopes or on the valley bottoms. Original source materials of the sediment are chiefly the silt loam soils and to some extent the underlying parent shales and limestones.

CONCLUSIONS AND RECOMMENDATIONS

The rate of sediment accumulation measured in Lake Olathe shows that the erosion rate in the drainage area as a whole is comparatively high. The average annual deposit in the reservoir amounts to 11.2 acre-feet, or about 3.8 tons (125 cubic feet) for each acre of drainage area. Rapid sheet erosion on unprotected cultivated fields is the chief cause of the high rate. If the average dry weight of the reservoir sediment is 60.4 pounds per cubic foot,[6] and that of the soil in the drainage area is 82.4

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[6]See footnote 4, page 14.

pounds per cubic foot,[7] the measured rate of sedimentation indicates that the maximum time required to remove 1 inch of soil from the entire area is about 40 years.[8]

Municipal authorities of Olathe have recognized the danger of high silting rates and have protected most of the slopes around the lake by developing the grassed and wooded park area. Some additional reduction in the silting rate might be obtained by building check dams in the two upper arms, for example, in segments 21 and 33. The major factor, however, which is excessive sheet erosion throughout the drainage basin, cannot be controlled by municipal action. Adequate protection of the reservoir from continued high silting rates will require application to the entire drainage area of a comprehensive and thorough program of scientific erosion control, which would be doubly beneficial by also protecting the lands from the excessive soil losses now occurring.

The results of the detailed sedimentation survey of Lake Olathe are summarized in the following tabulation.

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[7]Based on the average of the volume weights given for the surface and three upper horizons of five silt loams (corresponding to the predominant soils in this drainage area) by Middleton, H. E., Slater, C. S., and Byers, H. G. The physical and chemical characteristics of the soils from the erosion experiment stations--second report. U. S. Dept. Agr. Tech. Bull. 430:21, 1934.

[8]This figure does not allow for sediment that has been bypassed during the several days of overflow following unusually heavy rains.

Summary of data on Lake Olathe, Olathe, Kans.

	Quantity	Unit
Age[1]	4.9	Years
Watershed area[2]	6.2	Sq. miles
Reservoir:		
Area at spillway level:		
Original	58	Acres
At date of survey	58	Acres
Storage capacity to spillway level:		
Original	532	Acre-feet
At date of survey	477	Acre-feet
Capacity per square mile of drainage area:[2]		
Original	85.81	Acre-feet
At date of survey	76.94	Acre-feet
Sedimentation:		
Total sediment	55	Acre-feet
Average annual accumulation:		
From entire drainage area	11.2	Acre-feet
Per 100 square miles of drainage area[3]	184	Acre-feet
Per acre of drainage area:[3]		
By volume	125.05	Cubic feet
By weight[4]	3.78	Tons
Depletion of storage:		
Loss of original capacity:		
Per year	2.11	Percent
To date of survey	10.34	Percent

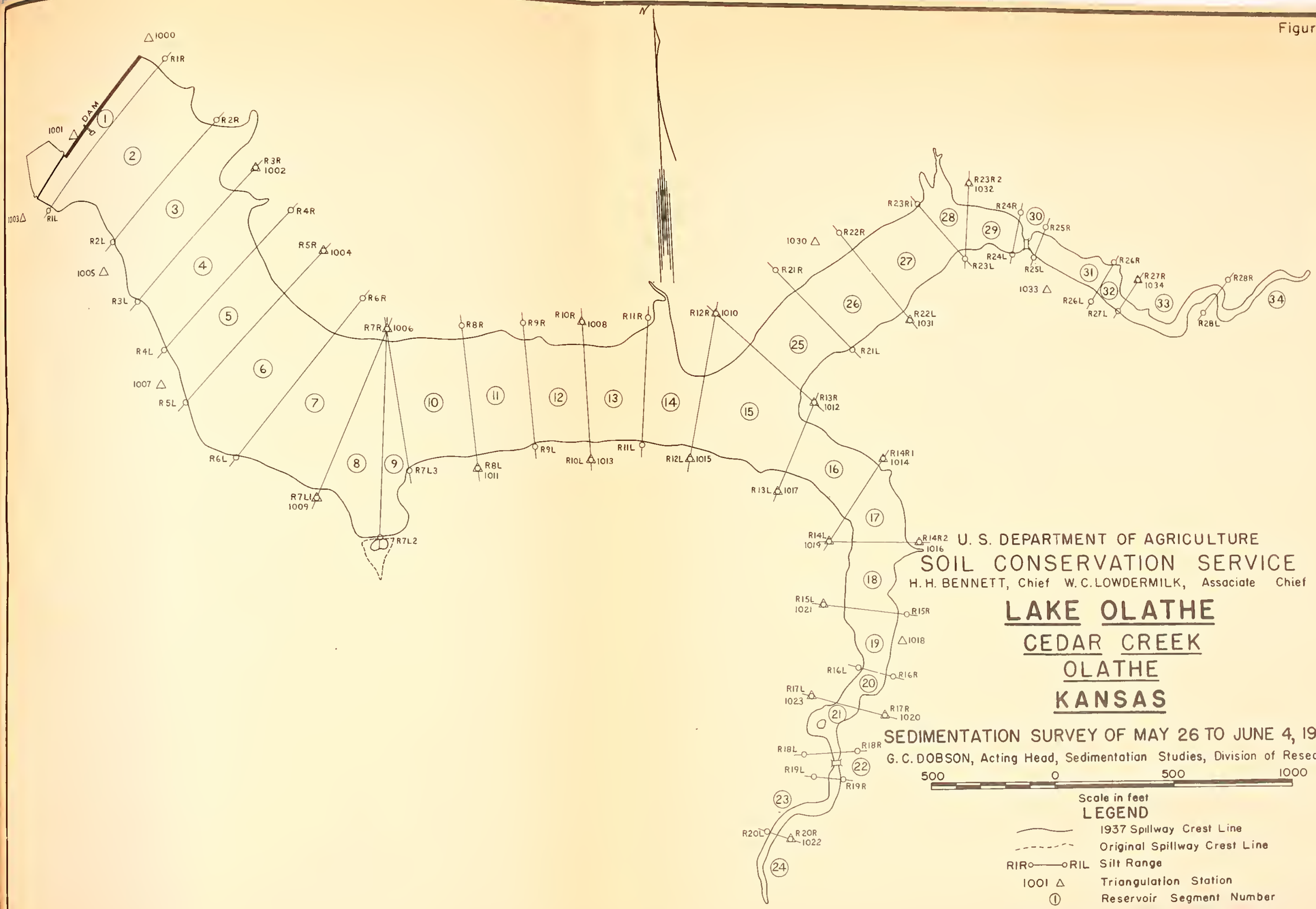
[1] Storage began July 1932; average date of survey, June 1937.

[2] Including area of reservoir.

[3] Excluding area of reservoir.

[4] Based on an average dry weight of 60.4 pounds per cubic foot, for four samples, computed from the moisture content (table 2) and an assumed specific gravity of 2.6.

Figure 4



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LAKE OLATHE

CEDAR CREEK

OLATHE

KANSAS

SEDIMENTATION SURVEY OF MAY 26 TO JUNE 4, 1937

G. C. DOBSON, Acting Head, Sedimentation Studies, Division of Research

500 0 500 1000

Scale in feet

LEGEND

- 1937 Spillway Crest Line
- Original Spillway Crest Line
- R1R—R1L Silt Range
- 1001 △ Triangulation Station
- ① Reservoir Segment Number

Louis M. Seavy, in Charge of Field Survey

0-1906

6-25-37